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to occur in the evening; but the readings of an interior thermometer would be higher in summer than in winter on such an evening.

(3) This is possibly due to the influence of the walls of the room, whose sub-permanent temperature is higher in summer than in winter. Circumstantial evidence of this influence is perhaps afforded by a break of continuity when fires are lighted or given up in the adjacent buildings.

(4) Regarding the matter from another point of view, the internal temperature depends simply upon the difference of external temperature from the average.

(5) When the shutters of the room are thrown open a re-adjustment of temperature proceeds somewhat rapidly for about an hour, and also afterwards, but more slowly. But it is a *rise* of temperature, and is probably due to the turning up of the gas simultaneously with the opening of the shutters.

(6) The interior temperature is generally higher with easterly winds than with westerly.

The Orbit of τ Cygni. By S. W. Burnham, M.A.

The companion to this star was discovered by Alvan G. Clark in 1874, October, with the 26-inch object glass, which was subsequently mounted at the McCormick Observatory. At this time the new pair was not difficult, and it was measured on many nights in the few years following by Dembowski with an instrument of about seven inches aperture. His observations were the first to show that the small star was in motion, and they continued long enough to prove a change of about 30° in angle, with some diminution of the distance. It was soon evident that this was orbital motion. The large star was known to have a large proper motion, amounting annually to 0″·484 in the direction of 17°·3, and the measures showed that this belonged to the small star as well, and that they must form a physical system. The companion was also measured by other observers from time to time, but very little was done for some years following 1880. It had become a much closer and more difficult object, and like all similar pairs it was neglected by many observers with instruments sufficiently powerful to measure it properly.

When my work in this line commenced at the Lick Observatory, I placed this pair on the working list, and observed it regularly every year as long as I remained there. By this time the change in distance of the components had made it a rather difficult pair with the 36-inch, except under very favourable conditions.

Gore in 1886, using the measures down to 1885, computed a provisional orbit of this pair, and found a period of 53·87 years (A. N. 2749). Some of the measures were discordant, and the

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arc was too small to give any very good result. The apparent orbit found at that time is shown in Fig. 1, and all the measures as used in the computation are accurately laid down to scale. It will be observed that the distance errors are very large, and that almost any ellipse would represent the positions equally well. In fact, a straight line will do this as a whole better than anything else. When the later measures at Mount Hamilton were made, it was clear that the apparent orbit must be represented by a very different ellipse, and therefore special attention was given to measuring the companion with all possible care. The arc passed over is now nearly 180°, and with a sufficient number of reliable measures a good orbit should be made. The following are all the published measures of this pair, arranged in chronological order:—

1874·89	162°·6	1″·11	2*n*	Newcomb
1875·12	174·5	1·24	2*n*	Dembowski
1875·69	170·5	1·32	3*n*	Dembowski
1876·79	161·5	1·24	2*n*	Dembowski
1876·83	166·9	1·62	2*n*	Waldo
1876·90	160·2	1·03	2*n*	Hall
1877·70	155·3	1·26	8*n*	Dembowski
1878·41	150·0	1·06	1*n*	Burnham
1878·54	147·5	1·09	3*n*	Dembowski
1878·76	158·8	1·09	2*n*	Hall
1879·50	148·3	0·90	2*n*	Burnham
1879·75	147·3	0·98	6*n*	Hall
1880·77	137·4	1·04	1*n*	Frisby
1883·88	159·2	...	3*n*	Seabroke
1885·52	116·3	1·08	3*n*	Tarrant
1885·73	100·7	0·62	1*n*	Hall
1886·78	80· ±	0·5 ±	1*n*	Hough
1887·76	56·4	0·4 ±	1*n*	Hough
1889·49	36·5	0·50	4*n*	Burnham
1890·54	20·5	0·54	3*n*	Burnham
1891·49	12·4	0·61	3*n*	Burnham
1891·69	9·3	0·52	3*n*	Hall
1892·40	2·3	0·61	3*n*	Burnham

It is obvious that some of these measures are of no value in an investigation of the relative motion, and that if any trustworthy conclusion is reached, it must be by rejecting doubtful and incomplete measures, and combining those made on a proper number of nights and by the most experienced observers. There-

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fore, as a preliminary step to laying down the positions to scale, I have selected the following:—

1875·46	172°·1	1″·29	5*n*	De.
1876·85	160·8	1·14	4*n*	De.–Hl.
1877·70	155·3	1·26	8*n*	De.
1878·57	152·1	1·08	6*n*	De.–Hl.–β
1879·62	147·8	0·94	8*n*	Hl.–β
1880·77	137·4	1·04	1*n*	F.
1885·73	100·7	0·62	1*n*	Hl.
1889·49	36·5	0·50	4*n*	β
1890·54	20·5	0·54	3*n*	β
1891·59	10·8	0·56	6*n*	Hl.–β
1892·40	2·3	0·61	3*n*	β

These observations are shown on Fig. 2, which is a photographic reduction of the large drawing, by the white circles connected by radial lines with the central star. An examination of these positions shows that the angular motion from 1875 to 1880 is too rapid when compared with the observed places 1889 to 1892; or the motion for the latter interval should be increased to make the areas described proportional to the times. The measures in the first interval are by the most experienced observers with the micrometer, and they are means of a sufficient number of nights to give presumably good results both in angle and distance. The last series of measures were made with the best telescope for the purpose in the world. I used every precaution to get good measures. They were made with a power of at least 1500, with favourable atmospheric conditions, and are consistent with each other. If we assume that the errors are uniformly distributed, which in cases of this kind is certainly not likely to be the fact, and that the angular motion and the distances are too large for the first interval, and correspondingly too small in the second, we find that the apparent ellipse which will satisfy the times requires corrections to the measures which are apparently inadmissible, and that it is necessary to wait for further measures in order to determine where the truth is.

There always remains in an example like this, where observations have some inconsistency when considered together, another method of treating them, which might be termed the heroic treatment, by the introduction of another star which shall account for and explain the apparent anomalies. It is always easy to do this, since one is not hampered by any restrictions, and can assume anything to supply the apparent deficiency shown by the actual observations.

It is obvious from an inspection of the observed positions shown on the diagram what the general character of the supposed

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invisible star must be to harmonise the observations. Let us assume that the Clark companion is attended by a "dark" sun of equal mass, the two revolving about the common centre of gravity in an orbit whose plane is at right angles to the line of sight. For the revolution of these stars we may take 17·6 years, since this will answer the purpose as well as any other, and further assume that their apparent distance is a quarter of a second, the position angle of the invisible star being zero at the date of the first measures, and the motion retrograde. Then for the dates of the respective measures the angles are as follows:—

1875·46	P = 360°·0	1885·73	P = 150°·0
1876·85	331·6	1889·49	73·1
1877·70	314·1	1890·54	51·6
1878·57	296·4	1891·59	30·2
1879·62	274·9	1892·40	13·6
1880·77	251·4		

The positions of the dark star at the several dates are indicated on the diagram by dark circles connected by straight lines with the observed positions of the real star. These are omitted for the observations between 1875 and 1880 to avoid confusing the diagram. The distance between the two stars is 0″·25, and of course the centre of gravity is at the middle of the line joining the two circles.

The next step was to draw an ellipse as accurately as possible through the centre of gravity at the various epochs, and after several trials the ellipse shown in the diagram, Fig. 2, was made. When this was examined, and the areas described by the line drawn from the principal star to the centre of gravity of B and C compared with the corresponding times, a very satisfactory agreement was found. The following are the errors of the angles and distances:—

1875·46	0°·0	−0″·07	1885·73	−8°·0	0″·00
1876·85	+2·5	+0·08	1889·49	−2·7	0·00
1877·70	+2·3	−0·06	1890·54	−1·1	−0·01
1878·57	−0·4	+0·10	1891·59	+3·0	0·00
1879·62	−4·0	+0·18	1892·40	−3·1	−0·03
1880·77	0·0	0·00			

Doubtless these errors could have been differently and possibly better distributed, but the variations are small, and will compare favourably with those of most of the computed orbits where the measures are easily made. This harmonises all the measures in angle and distance, and whatever the probabilities may be as to the existence of a disturbing third body, they are at least as strong in this case as in any other instance where a

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similar assumption has been made. This ellipse also represents the observed positions of the known companion, leaving the third star out of the question, as well as any which can be drawn at this time, but it will be seen that the errors of the measures are very much larger in angle and distance, and certainly larger than they should be in first-class observations.

The following elements of the orbit are found from this ellipse :—

$$P = 36 \cdot 5 \text{ years}$$

$$T = 1893 \cdot 1$$

$$e = 0 \cdot 24$$

An ephemeris for the visible companion star is easily made from the apparent orbit. The following are the angles and distances of the companion, according to this theory, as they should appear from the measures at these times :—

	°	″
1893·40	350·0	0·62
1894·40	341·6	0·64
1895·40	332·3	0·64

Before treating this matter very seriously, I would suggest the propriety of waiting until additional observations are made. It may be that the third star can be dispensed with. In any case this pair should be carefully observed each year. A few good measures will be of more value than any amount of speculation. It is evident that the companion can be measured in every part of the orbit. In double star matters we can afford to wait longer for theories than for results with the micrometer. Nor will it do to place too much reliance upon residuals, and the apparent agreement of observations with a proposed theory, since it must be a very poor theory which will not accurately fit the known facts it was intended to explain. It is the subsequent observations which are dangerous to a preconceived theory.

Chicago :
April 20.

Photograph of the Cluster M. 35 *Geminorum.*
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 35 *Geminorum*, R.A. $6^h\ 2^m$, Decl. $24^\circ{\cdot}21'$ north, was taken on the 7th February, 1893, with exposure of the plate during 66 minutes. It is No. 1360 in the *General Catalogue*, and is described by Sir J. Herschel as very large; considerably rich; pretty compressed; stars 9th to 16th mag., about 100 stars in one field.

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